Murchison's on page 103, in connexion with the Aymestry limestone.

The author mentions, but does not definitely accept, Prof. Hull's correlation of the Devonian rocks. Throughout the work, and particularly in the Carboniferous section, great care has been taken to show and where possible give the origin of the economic value of the rocks. A little more stress should have been laid on the relations of the Coal-measures to the underlying rocks, and one might notice here the absence of the Dudley, Sedgeley, and other inliers from the South Staffordshire coal-field on the map. An important feature consists in the description of Palæozoic rocks from all the deep borings (a list of these forms the first appendix); and a good section to express the present state of knowledge on the deep-seated geology of the London Basin is given on page 202.

The Permian and Lias form a single system, the Poikilitic, which is included in the Mesozoic, the author being guided by the widespread discordance between it and the older rocks. It is not quite easy to understand all the tables (pp. 286, 470), but these only echo the difficulties which exist in the rocks themselves. It would have been as well if the Yorkshire Cornbrash had found a place after the Upper Estuarine on page 321. A good opportunity was missed of discussing the anomalous beds of Faringdon and Blackdown, particularly in relation to Mr. Starkie Gardner's recent papers on kindred questions; and we should have liked to see the grit phases in the Jurassic clays of the eastern counties more accurately defined. A section might have been introduced to show the thinning of the Gault and growth of the Cambridge nodule beds; and Mr. Sollas's work on flints ought not to have been omitted.

The Upper Eocene beds are classed as Oligocene, but the Brockenhurst bed is put in its true place in the Headon.

There are some very suggestive remarks on the connexion between health and geology, between villages and springs and consequently the outcrop of porous rocks, and on the effects of percolation of spring and sea water through rocks. The section on igneous rocks is of necessity somewhat vague and unsystematic from its brevity, but room has been found to treat the volcanic rocks historically; the Nuneaton diorites are intrusive in pre-Carboniferous rocks only. There are concluding chapters on metalliferous deposits, and on scenery and geology, the latter containing a useful list of hills, valleys, plains, and forests.

A little more space might with advantage have been spent in indicating with greater fulness what is known of the physical geography of the different periods, and epochs of earth movements, their dates, directions, and effects should have been more fully dealt with in the last chapter. A capital synopsis of the animal kingdom is furnished in an appendix by Mr. Edwin T. Newton; and a grand index, occupying 45 pages of three columns each, and giving the dates of the birth and death of authors referred to, closes the volume, which is an excellent summary of the present state of our knowledge of British geology. The author has worked conscientiously and well, and that we have been able to suggest so few additions clearly shows that his labour has not been in vain.

W. W. W.

A TREATISE ON GEOMETRICAL OPTICS.

A Treatise on Geometrical Optics. By R. S. Heath, M.A., D.Sc., Fellow of Trinity College, Cambridge, Professor of Mathematics in the Mason College, Birmingham. Demy 8vo, pp. xvii. 356. (Cambridge: University Press, 1887.)

THIS treatise is based on the conception of a beam of light as consisting of a system of rays, which obey the laws of reflexion and refraction. The transformations of such a system and the construction and properties of optical instruments are deduced, so far as the latter are capable of explanation from this point of view.

In confining himself to geometrical optics in this sense, the author follows the mode of division of the science which has been usually adopted in text-books in this country, through the succession of Cambridge treatises by Coddington, Griffin, and Parkinson, and Lloyd's "Treatise on Light and Vision." The subject then splits up naturally into the theory of reflexion and refraction of systems of rays, which is in fact a department of geometry; and the more special discussion of the nature of optical instruments and the forms and positions to be given to their refracting surfaces to diminish spherical and chromatic aberration, which allies itself with the technical science of optical construction.

The book begins with a short chapter on the nature and properties of light, in which the theory of illumination is worked out as a consequence of the experimental fact that self-luminous surfaces appear equally bright in all directions and at all distances. The second and third chapters contain the statement, in geometrical and analytical form, of the laws of reflexion and refraction, and the investigation of conjugate foci for direct pencils.

In Chapter IV. the subject of refraction through lenses and systems of lenses is treated, use being made of the symmetrical analysis, by means of the convergents of continued fractions, to determine the principal points of a system whose refracting surfaces are specified. Free use is also made of the cardinal points of the system in the semi-geometrical manner introduced by Möbius. The following chapter is devoted to an account of the general analytical investigation by means of which Gauss placed the whole theory on an independent basis. The notion of the equivalent lens is here introduced to some practical purpose, for the investigations of this and the preceding chapter enable the author to specify the exact character of the equivalence that can be secured by a single lens or a single refracting surface: viz. that if the lens or surface occupied the position of one of the principal planes of the system, it would refract any beam incident along its axis into the same configuration as it actually possesses when it emerges through the other principal plane of the instrument; so that, neglecting aberrations, the equivalence holds in every sense except as regards the displacement along the axis, and is therefore complete for most practical purposes.

The theory of caustics is treated, chiefly by analytical methods; and the existence of wave-surfaces, which cut the system of rays at right angles in an isotropic medium, is established geometrically.

Chapter VII. is devoted to the discussion of the spherical aberration of direct pencils, which is perhaps

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one of the most difficult parts of the subject to present in an elegant manner, on account of the non-symmetrical character of the necessary approximations. The treatment here given seems to leave nothing to be desired.

Chapter VIII. begins with an exposition of the properties of a general system of rays: this with the cardinal result that the rays are all bi-tangents to a focal surface is ascribed to Kummer. They had, however, been previously given by Hamilton in his memoir on "Systems of Rays," in the discussion of ray-systems in a crystalline medium where the wave-surface no longer cuts the rays at right angles; and he in turn refers back to the same papers of Malus which contain the theorem of orthogonality in isotropic media.

The theory of the characteristic function is next applied to the solution of the general problem of the refraction of a narrow beam at a surface of double curvature; and to the analytical determination of the relation between the forms of such beams before and after passing through a general optical instrument whose internal structure is not specified. In these discussions the author has closely followed a series of papers by Clerk Maxwell which appeared about fifteen years ago in the Proceedings of the London Mathematical Society, and which presumably were to find a place in a book on optics then contemplated by their lamented author. It does not seem to have been much noticed in this country that the same formulæ for oblique refraction were developed a long time ago by Sturm and others, in a direct geometrical manner, from Malus's theorem; but the conciseness and precision which arise from defining a beam by means of its characteristic function give them an enhanced importance in optical theory. Their application is here given to some cases which we do not remember having seen published before: thus the modification impressed on a beam by refraction centrically through a single thin lens is expressed by means of very simple formulæ, from which several properties of considerable elegance and some practical value might be directly drawn.

The theory of dispersion and achromatism is treated in the ordinary way. In the chapter on vision are introduced discussions, chiefly from Helmholtz, of the mechanism of accommodation and the principles of binocular vision. Then follows a clear and valuable chapter on telescopes and microscopes, a chapter on miscellaneous optical instruments, and a brief account of atmospheric refraction, mirage, rainbows, and halos.

It may seem ungracious to expect more where so much is given, but we could have wished that the theory of refraction through general systems had been treated more from an historical standpoint. A difficulty often felt in this part of the subject arises from the way in which the geometrical and analytical methods of different writers are liable to be intermixed. The book was probably in the press before a recent note by Lord Rayleigh had brought again into prominence the large share taken by the English opticions of last century, notably Cotes and Smith, in the development of the general theory of this branch of the subject.

The list of treatises and memoirs might be improved by consulting the bibliographies given by Helmholtz and Verdet.

It is a misfortune incident on the scheme of the book that it is seldom able to say the last word in relation to the more delicate arrangements of telescopes and microscopes, where diffraction plays an important part. This becomes very patent, for example, in the account of immersion objectives. The theory of diffraction as applied to optical construction is for the most part purely geometrical, and it would much increase the value and interest of books on geometrical optics if that theory were explicitly included, and the subject introduced by the consideration of light as wave-motion, instead of the artificial conception of the reflexion and refraction of rays.

As is usual in English text-books, selections of problems have been added at the ends of the chapters. In this case, Cambridge examination-papers of recent years have been largely drawn upon for questions, with the result that some are included which are not of much value as illustrations of the subject, though they may be very useful as tests of mathematical power. Indeed it seems open to question whether the practice of adding large collections of examples is not now overdone in this country; it certainly in some cases tends to unfit the books which contain them for the use of students who do not possess the advantage of tuition, or some guidance in selecting the few that will be of value for them.

The treatise is, on the whole, a most welcome addition to our optical text-books. Much of its contents, though fundamental and elementary, has only hitherto been accessible in English through Mr. Pendlebury's treatise on "Systems of Lenses"; and there is more that now appears in a text-book for the first time. The printing and general appearance of the book reflect great credit on all concerned with it. J. LARMOR.

OUR BOOK SHELF.

Shores and Alps of Alaska. By H. W. Seton Karr, F.R.G.S. (London: Sampson Low, 1887).

THIS is a very interesting account of a journey of exploration in a country which, as the author says, is probably destined soon to become better known. The most important part of the book is that which relates to the attempt made by Mr. Seton Karr and his companions upon Mount St. Elias. When this attempt was made, the combined "alpinism" of the climbers was "insignificant." Nevertheless, they achieved considerable success, and the writer has been able to present a vivid and striking record of their observations. The height of Mount St. Elias was differently estimated by the old navigators, and Mr. Seton Karr points out that it is the only mountain the real height of which has exceeded the first estimates made of it. The latest determination taken from Yakatat and from the United States Coast Survey schooner *Yukon*, gives 19,500 and possibly 20,000 feet. From its massive shape the mountain does not convey the impression of being quite so high as this, although "its whole altitude is presented to the eye, from its sharp summit down to the ocean at its foot." Of the scenery of which Mount St. Elias is the most prominent feature, Mr. Seton Karr writes most enthusiastically. He even goes so far as to say that "without a doubt the scenery at Yakatat is the most wonderful of its kind in the whole world." Seen early in the morning, when the air is remarkably transparent, the mountains seem "too ethereal to have any actual existence." The observer feels that "they cannot be anything except some unholy illusion that must dissolve and disperse when the sun rises."

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